CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage, https//chimie-biologie.ubm.ro/carpathian_journal/index.html

A REVIEW ON NUTRITIONAL COMPOSITION AND PHARMACOLOGICAL EFFECTS OF GUAVA; (*Psidium Guajava* L.)

A.M.G.N. Rathnayake[1]✉, S. Maathumai[1] ,Tharshiga.T[2]

[1]Faculty of Animal Science and Export Agriculture, Uva Wellassa University, Badulla
[2] Faculty of Applied Sciences, Uva Wellassa University, Badulla
✉*gayathri@uwu.ac.lk*

https://doi.org/10.34302/crpjfst/2024.16.1.12

Article history:
Received: May 12th , 2023
Accepted: February 22nd, 2024

Keywords:
Antioxidant activity;
Anticancer property;
Health benefits;
Nutritional composition.

ABSTRACT

Guava *(Psidium guajava* L.) is a renowned fruit for its nutritional and medicinal significance. It is known as a *super fruit* attributable to its promising dietary properties. Its various components, including fruits, leaves, seeds, and bark, exhibit various chemical constituents, such as β-carotene, ascorbic acid, flavonoids, guaijavarin, guajivolic acid, tannins, linoleic acid, linolenic acid, and carotenoids. Throughout history, Psidium guajava has been extensively utilized in traditional medicine and ethnomedicine for diverse ailments including wound healing, regulation of blood glucose levels, ulcer treatment, alleviation of tooth pain and diarrhea, as well as management of digestive issues, gastroenteritis, dysentery, and rheumatic pain across various cultures. Notably, both leaves and fruits of *Psidium guajava* demonstrate remarkable pharmacological effects such as antioxidant, anticancer, antidiabetic, and anti-inflammatory properties, further aiding its medicinal applications.

1. Introduction

The *Psidium guajava* L. belongs to the genus *Psidium,* family *Myrtaceae*, which is native to tropical and subtropical regions of the world. Different types of *Psidium guajava* are available worldwide, including common types such as apple guava, yellow-fruited cherry guava, strawberry guava, and red apple guava. *Psidium guajava* fruits consist of green skin in immature stages and yellow skin in ripening with white, yellow, or pinkish flesh (Parvez et al., 2018; Sing *et al*., 2019). These fruits are sweet and tangy and are mostly eaten in raw forms when fruits are ripe or semi-ripe. The fruit has a unique fragrance when it's ripe, which is more or less similar to the fragrance in lemon rind. This is attributed to the availability of carbonyl compounds in the *Psidium guajava* fruits (Arshiya, 2013).

Psidium guajava is not just a fruit but a source of nutrients, including vitamin A, ascorbic acids, pantothenic acid, niacin, minerals including Na, Fe, Ca, P, carotenoids such as lycopene, and β carotene. *Psidium guajava* fruit is a rich source of vitamin C which is four times higher than that of oranges (Arshiya, 2013). The availability of various bioactive compounds in Psidium guajava fruits is attributed to its promising health benefits. However, these bioactive compounds vary with the maturity stage, soil conditions, variety, climatic conditions, and geographic location (Chauhan *et al*., 2015).

Psidium guajava leaves and bark are used in indigenous medicine as a treatment for gastroenteritis, dysentery, and colic pain of the intestine. Psidium guajava leaves are rich in flavonoids such as quercetin (Sing *et al*., 2019; Chauhan *et al*., 2015). Several ethnomedicinal uses of the *Psidium guajava* plant have been reported. Amazonia, Cuba, India, Trinidad, Philippines, Mexico, and Peru have used

Psidium guajava plant parts as ethno-medicine for dysentery, diarrhea, epilepsy, itch, piles, scabies, skin sores, sore throat, stomachache, wounds, and as an antiseptic and astringent. In India, leaves and bark of *Psidium guajava* are used to cure diarrhea, dysentery, vomiting, and sore throats and regulate menstrual cycles (Kamath *et al*., 2008).

Psidium guajava fruits are used to produce different food products including juice, nectar, jelly, jam, syrup, canned fruits, puree, fruit bars, ready-to-serve beverages, dehydrated products, flavoring agents in candies, cakes, biscuits, chocolate bars as additives to other fruit juices or pulp (Kanwal et al., 2016).

1.1.Taxonomical classification of *Psidium guajava L.*

Kingdom	Plantae
Subkingdom	Tracheobionta
Division	Magnoliophyta
Class	Magnoliopsida
Sub-Class	Rosidae
Order	Myrtales
Family	Myrtaceae
Genus	Psidium
Species	*Psidium guajava*

2. Plant morphology

Psidium guajava exists as a shrub or a small evergreen tree with branches, usually growing 1-6 m tall (Sing et al., 2019). The bark of the *Psidium guajava* is copper or reddish brown in color, smooth, thin, and easily flakes off. Flakes cover the greenish new bark; therefore, they give a spotted appearance to the plant with a combination of green and brown color. Branches of the *Psidium guajava* are twisted, bearing opposite leaves with a 4 – 10 mm long petiole. Some younger branches contain hairs in their stems. Leaves of the *Psidium guajava* are ovate-elliptic or oblong-elliptic in shape with obtuse or acute apices and obtuse bases, dark green in color. The lower side of the leaves contains hair when young. Flowers of *Psidium guajava* are fragrant, white in color, and consist of four to five white petals with many pale-yellow anthers (Sing et al., 2019; Vikrant et al., 2012).

The shape of *Psidium guajava* fruits are round, pear, or ovoid in shape and consist of remaining sepals (Calyx lobe). The peel of the fruit is sour and bitter, and it is green in color. Once the fruit ripens, the flesh turns pink, yellow, or white once it matures. Fruit contains edible seeds in its flesh. Based on the variety, the nature of seeds can be different, such as very hard to soft and chewable (Vikrant *et al*., 2012).

3. Nutritional Composition

Psidium guajava consists of different nutrients, including vitamins, minerals, fiber, fat, and protein. Nutritional composition can vary based on the variety, geographical region, and climatic conditions. *Psidium guajava* is considered a super fruit due to the presence of vitamin C, vitamin A, Niacin, Riboflavin, and various minerals, including potassium (Joseph & Priya, 2011). Single fruits of *Psidium guajava* contain a higher amount of vitamin C, which is four times higher than the oranges (Vikrant *et al*., 2012; Joseph & Priya, 2011). *Psidium guajava* has 68 kcal per 100g, which is considered low energy (Table 1). Minerals including K, Ca, Mg, Na, S, P, fe, Cu, B, and Zn were reported in the *Psidium guajava* fruits, which were obtained from 128 *Psidium guajava* accessions sampled from four regions of Kenya. K is the prominent mineral in the *Psidium guajava, accounting for* a mean value of 293.7 mg/100 g FW. Based on the color of the flesh amount of minerals present in the *Psidium guajava* fruit varies. White-fleshed *Psidium guajava* fruits exhibited more protein content and some minerals (K, Mg, Na, S, and B) than the red-fleshed ones (Chiveu *et al*., 2019).

Table 1. Nutritional Composition of *Psidium guajava* Fruit (Source: USDA)

Proximates	Minerals	Vitamins	Lipids
Water 80.8 g Energy 68 kcal Protein 2.55g Total lipid (fat) 0.95g Carbohydrate, by difference 14.32g Fiber, total dietary 5.4g Sugars, total 8.92g	Ca 18mg Fe 0.26mg Mg 22 mg P 40 mg K 417 mg Na 2 mg Zn 0.23 mg	Vitamin C, total ascorbic acid 228.3 mg Thiamin 0.067 mg Riboflavin 0.04 mg Niacin 1.084 mg Vitamin B-6 0.11 mg Folate, DFE 49 µg Vitamin A, RAE 31 µg Vitamin A, IU 624IU Vitamin E (alpha-tocopherol) 0.73mg Vitamin K (phylloquinone) 2.6 mg	Fatty acids, total saturated 0.272 g Fatty acids, total monounsaturated 0.087 g Fatty acids, total polyunsaturated 0.401 g

Table 2. *P. guajava* fruit composition

Fruit Composition	Amounts Recorded	References
Ascorbic acid	136.5 -220.4 10 mg/100 g FW and 360 mg/100 129.5 mg/100 g and 247.9 mg/100 g	Chiveu, et al. (2019), Gull et al. (2012)
TSS (Brix)	11% 7.64 %to 11.87% 9.35-11.88%	El-Sisy (2013), Gutiérrez et al (2008), Adrian et al. (2015)
Glucose	0.95 ± 0.08 g/ 100ml 1.11 g/100 g	Sanz et al. (2004), Chiveu, et al. (2019)
Fructose	2.74 g /100ml 2.81 g/100g 5.64 -7.64 g/100ml of juice	Sanz et al. (2004), Chiveu, et al. (2019)
Sucrose	6.2 -7.2 g/100ml of juice 0.57 g/100ml	Bulk et al. (1996), Sanz et al. (2004)
Protein	0.76 to 1.85%. 1.52%	Gutiérrez et al (2008), Chiveu, et al. (2019)
Acidity (as citric acid)	0.52 to 1.67%.	Gutiérrez et al (2008),

Psidium guajava has 68 kcal per 100g which is considered low energy (Table 1). Minerals including K, Ca, Mg, Na, S, P, Fe, Cu, B, and Zn were reported in the Psidium guajava fruits, which were obtained from 128 *Psidium guajava* accessions sampled from four regions of Kenya. K is the prominent mineral in the *Psidium guajava, accounting for* a mean value of 293.7 mg/100 g FW. Based on the color of the flesh amount of minerals present in the *Psidium guajava* fruit varies. White-fleshed *Psidium guajava* fruits exhibited more protein content and some minerals (K, Mg, Na, S, and B) than the red-fleshed ones.

Psidium guajava fruits contain the second richest vitamin C content among all fruits (Chen *et al*., 2006). The ascorbic acid content in Psidium guajava fruits in Kenya varies from 10 mg – 360 mg /100g of fruit Weight (Chiveu *et al*., 2019). In Pakistan, the ascorbic acid content of pulp and peel of fully ripe *Psidium guajava* varies between 29 mg /100g and 247mg/100g (Gull *et al*., 2012). The ascorbic acid composition of fully ripe *Psidium guajava* varies geographically (Chiveu *et al*., 2019).

In another study Correlation between the temperature of the area and the ascorbic acid content of fruits was recorded. The higher values were observed in high-temperature regions, while lower values were observed in moderate and colder regions. A Converse finding was reported in Thailand, whereas higher ascorbic acid content was exhibited in the winter season. In addition to the temperature, an increase in precipitation was also recorded as a reason for the increase in the ascorbic acid content (Chiveu *et al*., 2019; Taipong *et al*., 2005).

TSS values of *Psidium guajava* are demonstrated in Table 2. Fifteen *Psidium guajava* genotypes growing in similar conditions demonstrated TSS as 9.04-14.07 % (El-Sisy, 2013). In another two studies, reported TSS values of Psidium guajava fall *between*

9.35%-11.88% (Chiveu *et al*., 2019; Patel *et al*., 2011).

Further TSS values were changed with their regions and climatic conditions. TSS exhibited a positive correlation between temperature and a negative correlation with rainfall of the geographical region (Marsh *et al*., 1999).

Major sugar components in *Psidium guajava fruits* at the ripening stage are fructose and sucrose (Sanz *et al*., 2004; Bulk *et al*., 1999). During fruit development, total and individual sugar content increased. Once fruit reaches maturity, fructose, glucose, and sucrose account for 20%-48%, 14%-59%, and 21%-45% of total sugar content, respectively. In the development of fruit from the immature to ripening stage, fructose built within the fruit varies rapidly; hence, the fructose-to-glucose ratio is very low (Bulk *et al*., 1999).

Moreover, the fructose to glucose ratio was recorded as 0.35 in *Psidium guajava* fruits (Sanz *et al*., 2004; Bulk *et al*., 1999). It is known that fructose resulted in a lower level of post-prandial hyperglycemia, which would result from the same intake of glucose. Therefore, the fructose-to-glucose ratio of Psidium guajava has a high level of dietary significance.

4. Medicinal and Pharmacological Effects of Psidium guajava

Various plant parts of the *Psidium guajava* have been used for different medicinal purposes globally. The availability of various constituents in plant parts, as per Table 4, gives medicinal value to the plants. Ethnomedicinal applications of *Psidium guajava* are demonstrated in Table 3.

4.1. Antimicrobial activity

Effect of *Psidium guajava* on many pathogenic microorganisms *Staphylococcus aureus, Streptococcus mutans, Pseudomonas aeruginosa, Salmonella enteritidis, Bacillus cereus, Proteus spp., Shigella spp. and Escherichia coli* were examined (Adrees *et al*., 2010). These microorganisms cause infections in the intestines of humans, and the inhibitory activity of extracts of *Psidium guajava* leaves and roots was analyzed against these pathogens (Adrees *et al*., 2010). Gallocatechin in *Psidium guajava* leaves demonstrated antimutagenic activity against *E. coli*. Leaves and bark extracts of *Psidium guajava* exhibited in vitro toxic action against different microorganisms including bacteria (Chah *et al*., 2006). *Psidium guajava* fruit and leaf extract have been used to determine their effectiveness against the acne-causing bacteria *Propionibacterium acnes* (Qadan *et al*., 2005). *Psidium guajava* extracts were checked against tea tree oil, doxycycline, and clindamycin antibiotics, which have proven to cure acne. Results demonstrated that leaf extracts of *Psidium guajava* were effective against acne-casing bacteria *Propionibacterium acnes* (Qadan *et al*., 2005). The activity of *Streptococcus mutans* was inhibited by the active flavonoid compound - quercetin-3-Oalpha-l-arabinopyranoside (Guaijaverin) in leaves of *Psidium guajava*, which has high antiplaque activity.

The antimicrobial activity of *Psidium guajava* is linked to the availability of guaijaverin (Joseph & Priya, 2011).

The root extract of *Psidium guajava* consists of different antibacterial compounds. Four antibacterial compounds have been separated using column chromatography and antifungal activity was revealed in ripe fruits of *Psidium guajava* against *Arthrinium sacchari* and *Chaetomium funicola* strains (Prabu *et al*., 2006; Arima & Danno, 2002; Sato *et al*., 2000).

Table 3. Ethno-medicinal applications of *Psidium guajava*

Parts of the *Psidium guajava*	Ethno-medicinal applications	Reference
Leaf	Curing wounds, lowering blood glucose level, treating ulcer, curing tooth pain, diarrhea, treating digestive problems, gastroenteritis, dysentery, rheumatic pain, used to force out placenta after childbirth, curing plethora, treating inflammations, treatment for diabetic Mellitus, treating colds, treating rashes and itchiness, sore throat, treatments for worms, treating bacterial infections, treating vaginal discharge problem, to purifying blood, treating constipation, febrifuge, astringent, skin infections, mouth swelling	Gutiérrez et al (2008), Leonti et al. (2001) Oh et al. (2005),
Fruit	Treatment for dysentery, astringent, treating skin problems respiratory sufferings, wounds, treatment for fever, treating dehydration, vaginal bleeding, cough, treating inflammations, ulcers, diarrhea, and digestive problems.	Gutiérrez et al (2008) Jansen and Mendez.1990 Leonti et al.(2001), Smith and Nigel (1992)
Bark	Treatment for dysentery, astringent, treating skin problems. Treatment for diarrhea and amoebic suffering	Gutiérrez et al (2008) Tona et al. (1998)
Flower	Treating indigestion, cholera, diarrhea, sore throat, and vaginal discharge sufferings	Gutiérrez et al (2008) Tona et al. (1998) Cybele at al. (1995)
Root	Treatment for wounds, diarrhea, and ulcer	Gutiérrez et al (2008) Smith and Nigel (1992)

4.2. Cancer Treatment

Different phytochemical constituents in different parts of *Psidium guajava, as demonstrated in Table 4, are attributed to its cancer-prevention* properties. Several studies reveal that various chemicals found in the *Psidium guajava* leaves have effects on human cells, such as Psiguadials A, B, and guajadial, which inhibit the growth of prostate cancer cell lines. Young leaves of *Psidium guajava* contain high concentrations of isoflavonoids and polyphenols which inhibit the angiogenesis and cell migration processes (Sato *et al*., 2010)

Ascorbic acid, Apigenin, and Lycopene in the fruits of *Psidium guajava* have anticarcinogenic effects. The ability to prevent breast cancer by preventing cell proliferation of cancer cell lines was reported in *Psidium guajava* fruit extract (Oh *et al*., 2005). Antiproliferative activity of *Psidium guajava* fruits was tested against the human lung cancer cells (A549), human breast cancer cells (MCF-7), human hepatoma cells (HepG2), and human colon cancer cells (HT-29) through the MTT assay (Chen *et al*., 2015). Results revealed that different phyto compounds such as Catechin, Galangin, Homogentisic acid, Gallic acid, Kaempferol, and Cyanidin 3-glucoside were effective as antiproliferative agents.

Antitumor potential of leaves of *Psidium guajava* extracts was recorded along three cancer cell lines: PC3 (prostate), A549 (lung), and BT549 (breast) cancer (Alhamdi *et al*., 2019). Results demonstrated that *Psidium guajava* extract effectively inhibited the three types of cancer cells from proliferation. *Psidium guajava* leaves have cytotoxic effects on the HSC-2 cell line of human oral cancer (Pakpahan *et al*., 2003). Essential oils from the leaves have a cytotoxic impact on PC-3 cell lines, which was able to suppress tumors (Sato *et al*., 2000).

4.3. Antioxidant activity

Antioxidants are compounds that prevent or delay the oxidative damage of macromolecules caused by reactive oxygen species at low concentrations (Arshiya, 2013).

Several researchers have studied the leaf, fruit, seeds, and bark of *Psidium guajava* as potential sources of natural hydrophilic and lipophilic antioxidants (Taipong *et al*., 2005). Ascorbic acid, vitamin A, vitamin E, polyphenols, carotenoids, polysaccharides, and flavonoids are the major antioxidants and free radical scavengers (Chauhan *et al*., 2015; Joseph & Priya, 2011). Vitamin C and polyphenols are hydrophilic antioxidants while carotenoids such as β-carotene and lycopene are lipophilic antioxidants. The carotenoid content is high in *Psidium guajava* fruit compared to other fruits. Hydrophilic antioxidants are responsible for 99% of antioxidant activity (Taipong *et al*., 2005). The leaf and fruit of *Psidium guajava* are rich in strong polyphenol-like antioxidant compounds (Braga *et al.,* 2014). The polyphenols such as quercetin, narigin, catechins, rutin, caffeic acid, gallic acid, and chlorogenic acid are the strong antioxidants in *Psidium guajava*. The antioxidant content of *Psidium guajava* depends on various factors like variety, maturity, climate, soil, composition, geographic location, and storage conditions (Chauhan *et al*., 2015). The young *Psidium guajava* leaves showed higher antioxidant activity than matured leaves (Nantitanon *et al*., 2010)

Ultrasonication and homogenization were the best antioxidant extraction techniques for pink-flesh *Psidium guajava* fruits (Nantitanon *et al*., 2010; Musa *et al*., 2011). Further, using pure solvents for the antioxidant extractions was inefficient, and it is recommended to use 50% acetone in combination with aqueous rather than methanol and ethanol for efficient extraction. Another study reported that the ultrasonication extraction method yielded high amounts of phenolic antioxidants in *Psidium guajava* leaves and showed the highest antioxidant activity (Nantitanon *et al*., 2010). Moreover, they reported that hot water was the best solvent to extract active antioxidants. Thaipong *et al*., (2005) used methanol for extraction of hydrophilic and lipophilic antioxidants from white and pink fleshed *Psidium guajava* fruits. He and Venant (2004) extracted the antioxidants effectively from dried ground leaves of *Psidium guajava* with 50% aqueous ethanol. The variety of *Psidium guajava*, the polarity of the solvent used (Musa *et al*., 2011), and the type of extraction method (Nantitanon *et al*., 2010) may influence the extraction efficiency of antioxidants (Musa *et al*., 2011). The Folin–Ciocalteu index (FCI), ferric-reducing antioxidant power assay (FRAP), 2,2- azinobis (3-ethyl-benzothiazoline-6-sulfonic acid) (ABTS), the oxygen radical absorption capacity (ORAC) and 1,1-diphenyl-2-picrylhydrazyl free radical-scavenging capacity (DPPH) were used to determine the antioxidant activity of *Psidium guajava* (Musa *et al*., 2011). Thaipong et al. (2005) suggested that the FRAP technique was best for determining the antioxidant activity of *Psidium guajava* fruit since it was simple, showed high reproducibility, rapid performance, and the highest correlation with total phenolics and vitamin C. The antioxidant activity of phenolic compounds depends on the position and degree of hydroxylation of the ring structure and its molecular structures (He & Venant, 2004). Sato et al (2000) reported in their review that the fresh *Psidium guajava* skin has higher total phenolic content than the pulp.

The *Psidium guajava* leaves contain a broad spectrum of flavonoids, ascorbic acid, and polyphenols (Gayathri & Kiruba, 2014; Joseph and Priya, 2011). Braga et al. (2014) found that the total phenolic and flavanol contents of ethanol extracts of Psidium guajava leaves were 766.08 ± 14.52 mg/g and 118.90 ± 5.47 mg/g, respectively, and the extract showed effective antioxidant activity of 87.65% in the DPPH assay. He & Venant (2004) noted that the total phenolic content of dried *Psidium guajava* leaves was 575.3 ±15.5 mg (GAE)/g on a dry basis and 82.74%. The antioxidant activity was observed for the DPPH assay conducted with the ethanolic leaf extract at a concentration of 0.5 mg/ml, and the 50% radical scavenging activity (EC50) of ethanolic leaf extract against DPPH was 54 mg/ gram of DPPH. Nantitanon et al. (2010) reported that 24.30 ± 0.50 mM/mg of total phenolic content was recorded for the hot water extract of *Psidium guajava* young leaves (He & Venant 2004). The antioxidant activity was increased with the increasing concentration of leaf extract. It was reported that the polysaccharides in *Psidium guajava* leaves could be used as an antioxidant additive in the food industry (Kumar *et al*., 2021).

The *Psidium guajava* fruits showed more hydrophilic antioxidant properties than lipophilic antioxidant properties due to the presence of higher phenolic and vitamin C content than carotenoids. Further, they stated that the *Psidium guajava* fruits with white flesh showed high hydrophilic antioxidant activity due to the presence of higher phenolic content (33.3 µM TE/g FW) than the pink flesh fruits (ranging from 15.5 to 30.4 µM TE/g FW). The lipophilic antioxidant activity was also higher for white flesh fruits compared to pink flesh fruits, while pink flesh fruits had higher vitamin C content than white flesh fruits (Thaipong *et al*., 2005) and Omayio et al. (2019) have reported that the red-orange colored *Psidium guajava* fruits have higher levels of polyphenols, carotenoids, and pro-vitamins compared to yellow-green varieties.

Moreover, spectrophotometric analysis at 470 nm showed that the carotenoids (β-carotene) were absent in white flesh *Psidium guajava* and 0.78 to 2.93 mg/100 g were present in pink flesh *Psidium guajava*. Lycopene protects the skin from UV rays, and the lycopene content of pink *Psidium guajava* is twice the lycopene content of tomato (Arshiva, 2013).

Chen and Yen (2007) reported that the Psidium guajava leaf extract and Psidium guajava fruit extracts showed 94.4%-96.2% inhibition of linoleic acid oxidation at 100 µg/ml concentration. Further, they stated that the Psidium guajava leaf extracts had stronger antioxidant properties than dried Psidium guajava fruit extract, and based on the chromatogram, the ferulic acid (phenolic acid) was responsible for the antioxidant activity of *Psidium guajava* leaf and dry fruit extracts. Daily consumption of *Psidium guajava* is good for human health in preventing diseases such as cancers and cardiovascular diseases arising from oxidative stress (Thaipong *et al*., 2006).

4.4. Antidiabetic activity

Diabetes mellitus is one of the major and serious health problems in the world today (Mazumdar *et al*., 2015; Rawi *et al*., 2011). It is a carbohydrate metabolism disorder of the endocrine system that causes a rapid increase in blood glucose levels due to insulin secretion deficiency (Rawi *et al*., 2011; Mazumdar *et al*., 2015). Santosh Mazumdar et al. (2015) predicted that the number of people suffering from diabetes was 171 million in the year 2000, and it will be increased to 366 million in 2030. Sharma et al., (2012) also estimated that 366 million diabetes patients will be there in 2030, but Liu et al. (2015) reported that 552 million will be diagnosed with diabetes mellitus by the year 2030. Drugs such as biguanides, sulfonylurea, and thiazolidinediones are presently available to treat diabetes mellitus, but their use is restricted due to the side effects, secondary failure, and pharmacokinetic properties (Rawi *et al*., 2011). In traditional folk medicine, plants rich in phytochemicals and secondary metabolites have been used to treat diabetes for many years (Mazumdar *et al*., 2015;

Sharma, 2012). According to an ethnobotanical report, it was reported that about 800 plant species possess antidiabetic potential (Rawi *et al*., 2011).

Many researchers have reported that the bioactive compounds in *Psidium guajava* have strong antidiabetic potential (Luo *et al*., 2019)**.** The flavonoids, steroids, saponins, and polysaccharides (Joseph & Priya, 2011; El, 2018) in various parts of *Psidium guajava* (fruit, seed, leaf, and bark) as demonstrated in Table 4 are responsible for the antidiabetic activity (Rawi *et al*., 2011; Mazumdar *et al*., 2015). Bioactive compounds *in Psidium guajava* such as myrciaphenone B, flavonol glycosides, casuarictin and tellimagrandin, catechin and geraniin, quercetin and cyanidin-3-O-β-glucoside are responsible for the inhibition of carbohydrate-hydrolyzing enzymes and geraniin, gallic acid, naringenin, vescalagin, morin, quercetin, epicatechin and catechin are responsible for anti-glycation activity**.** *Psidium guajava* is a rich source of dietary fiber, which helps to reduce sugar levels in diabetic patients (Parvez, 2018; Cerio, 2016)**.**

The *Psidium guajava* leaf extract has been used traditionally in folk medicine to treat diabetes in East Asia (Mazumdar *et al*., 2015; Luo *et al*., 2019) and other countries like North America (Luo et al., 2019), Japan, and Africa. Deguchi and Miyazaki (2010) stated in a review there was not enough evidence on the antidiabetic activity of Psidium guajava leaf extract in clinical trials, and the therapeutic mechanisms and safety remain unclear. However, in 2000 the Japanese Ministry of Health, Labour and Welfare approved and recommended the *Psidium guajava* leaf tea which contains aqueous *Psidium guajava* leaf extract for pre-diabetes patients under ‘’Foods for Specified Health Uses” (FOSHU) and in both developed and developing countries and it is suggested to ingest consecutively with every meal as an alimentotherapy for better relief in prediabetic and diabetic patients. Another study revealed that the aqueous *Psidium guajava* leaf extract at a dose of 200 and 400 µg/ml showed effective antioxidant activity and improved insulin resistance by increasing the glucose uptake in normal and high glucose-induced insulin-resistant mouse FL83B cells in western blot analysis and significantly enhanced the glycogen content by modulating the insulin signaling pathway (Mazumdar *et al*., 2015)**.** A review study revealed that the alpha-amylase enzyme inhibition activity of Psidium guajava methanol extract was dose-dependent; 0.2 ml of plant extract showed only 27.8% inhibition, while 1 ml extract showed 96.3% inhibition (Parvez *et al*., 2018).

Researchers found that the phytochemicals in *Psidium guajava* trigger the glucose metabolic enzymes in liver tissues **(**Mazumdar *et al*., 2015). Further, he reported that the freshly prepared ethanolic *Psidium guajava* leaf extract at doses of 0.5 and 1.0 g/kg efficiently reduced the blood glucose level and lipid profile levels in the oral glucose tolerance test conducted with diabetic albino rats. Another study also stated that the leaf extract of *Psidium guajava* inhibited the increase of plasma glucose levels in alloxan-induced diabetic rats at 250 mg/kg in an oral glucose tolerance test (Rawi *et al*., 2011). Shukla and Dubey (2009) also found that the ethanolic and aqueous leaf extracts of *Psidium guajava* (300mg/kg of body weight) showed a mean percentage blood glucose reduction of 18.88% and 9.19%, respectively, for diabetic albino rats and they stated that ethanolic extract was better than aqueous extract. Polysaccharides extracted from *Psidium guajava* leaves significantly lowered the fasting blood sugar, total triglycerides, total cholesterol, glycated serum protein, and creatinine in an experiment conducted with diabetic mice **(**Luo *et al*., 2019). A research study reported that the *Psidium guajava* leaf extract individually or in combination with mango leaf extract (dose of 250 mg/kg body weight) showed an effective hypoglycemic activity and antidiabetic activity in streptozotocin-diabetic albino rats (Rawi *et al*., 2011)**.**

It was reported that the *Psidium guajava* fruit extract significantly reduced the blood glucose level in diabetic conditions and protected the pancreatic tissues including islet beta cells against lipid peroxidation (Taiyab *et al*., 2012)

Table 4. Chemical constituents present in plant parts of guava

Parts of *Psidium guajava*	Chemical presents	Reference
Fruit	Anthocyanin, Pectin, Lycopene, β-carotene, β-cryptoxanthin, Phosphoric acid, Oxalic acid, Mallic acid, Galaturonic acid, Aspartic acid, Ascorbic acid, Oleanolic acid, Psidium guajava coumaric acid, Ellagic acid, Pantothenic acid, Phenolic acids, Homogentisic acid, Gallic acid, Ursolic acid, Arjunolic acid, Oleandolic acid, Guajavanoic acid, Glucuronic acid, Flavonoids, Phenolic compounds (phenol triterpenes), benzaldehyde, Niacin, Quercetin, Saponin with oleanolic acid, Morin-3-O-α-L-lyxopyranoside, , Morin-3-O-α-Larabopyranoside, Catechin Cectin Guaijavarin, Guajivolic acid, Galangin, Tannins, linoleic acid, linolenic acid, carofenoid, hexanal, γ-butyrolactone, (E)-2-hexenal, (E, E)- 2,4-hexadienal, (Z)-3-hexenal, (Z)- 2-hexenal, (Z)-3-hexenyl acetate, 3-caryophyllene, nerolidol, 3-phenylpropyl acetate, 3-penten-2-ol and 2-butenyl acetate, Carboxyl compounds, Kaempferol, Cyanidin 3-glucoside, Apigenin, Limonene, β-Caryophyllene, Aliphatic Alcohols, Aliphatic Ketones, Aliphatic Aldehydes, Aliphatic ketones, Aliphatic esters, Terpene alcohol, Terpene Aldehydes, Terpene Ketones, Terpene Esters, Terpene oxides, Lactone, Furan, Acetal, Benzothiazole, β-caryophyllene hydrate, diacetyl, diethylene glycol, 5,6-dihydro-2H-pyran- 2-carboxaldehyde, 2,4-dimethyl 1,3-dioxane, monobutyl ether- 3,4-dihydro-8-hydroxy-3- ethyl-2-benzo-1H-pyran-1-one, isopentana, methylpyrazine, octyl methyl ether, Aromatic esters, Ketones and Aldehydeds, Essential oils [α-Pinene,β-Pinene, δ-2-Carene, α-Phellandrene, α-Terpinene, p-Cymene, Limonene, 1, 8-Cineole, cis-β-Ocimene, γ-Terpinene, Terpinolenea, Carvacrol, α –Terpineol, α-Copaene, α-Gurjunene, β-Caryophyllene, β-Copaene, β-Gurjunene, Aromadendrene, allo-Aromadendrene, α-Humulene, γ-Gurjunene, Aromadendrene, α-Humulene, β-Selinene, α-Selinene, Valencene, δ-Cadinene, α-	Arshiya, (2013) Oh et al. (2005), Chiari-Andreo et al. (2017), Biswas et al. (2019) Huang et al. (2011), Bontempo et al. (2012), Oliveira et al.(2010), Thuaytong and Anprung (2011) Liang et al. (2005)

	Calamenene, α-Calacorene, Germacrene B, Viridiflorol, Spathulenol, β-Caryophyllene-oxide, Daucol], Protocatechuic acid, Guavin B, Amritoside, Araban, Ascorbigen, Asiatic acid, Leucocyanidin, Mecocyanin, Rubixanthin, Criptoflavin, Neochrome, Lutein, Phytofluene, Copaene, Quercetin 3-α-L- arabinofuranoside, Quercetin-3-β-galactoside, Quercetin 3- β-D- galactoside, Avicularin. Amritoside, Ethyl octanoate, 3-phenyl propanol, (E)-2-hexanal, α-Humulene, Benzaldehyde, Butanal, Octonol, Ethyl octanoate, 6-methyl-5-hapten-2-one	
Leaves	Kaempferol, 3-O-xylosyl-rutinoside, Schottenol ferulate, 3-Methoxysinensetin, Quercetin 3-O-diglucoside, 3-O-acetilrhamnoside, 3-O-xylosyl-rutinoside, 3-O-xyloside and 3-O-(6''-malonyl-glucoside), Sesamolinol 4'-O-β-D-glucosyl (1->6)-O-bD-glucosid, Esculin, 3-Sinapoylquinic acid, flavonoids, tannins triterpenoids, saponins, sterols, alkaloids, Essential oils [α-Pinene,β- Pinene, δ-2-Carene, α-Phellandrene, α-Terpinene, p-Cymene, Limonene, 1, 8-Cineole, c is-β-Ocimene, t rans-β-Ocimene, rans-β, γ-Terpinene, Terpinolenea, Carvacrol, α –Terpineol, α-Copaene, α-Gurjunene, β-Caryophyllene, β-Copaene, β-Gurjunene, Aromadendrene, allo-Aromadendrene, α-Humulene, γ-Gurjunene, Aromadendrene, α-Humulene, β-Selinene, α-Selinene, Valencene, δ-Cadinene, α-Calamenene, α-Calacorene, Germacrene B, Viridiflorol, Spathulenol, β-Caryophyllene-oxide, Daucol], Gallic acid, Catechin, Epicatechin, Quercetin, Rutin, Vitamin E, Heneicosane, Pyrogallol, palmitic acid, Caryophyllene oxide, Alloaromadendrene, Sitosterol, α-Bulnesene, Squalene, Avicularin, Apigenin, Hyperin, Myricetin, Epigallocatechin gallate, Caffeic acid, Kaempferol-3-arabofuranoside, Isoquercitrin, Chlorophyll, Alkaloids, Saponins, Anthraquinones, Tannins, Terpenes, Flavonoids, Coumarins, Proanthocyanidins, Protocatechuic acid, Guavin B, , Amritoside, Araban, Ascorbigen, Methyl cinnamate, Eucalyptol, Azulin, Asiatic acid, Ferulic acid, Leucocyanidin,	Bulk et al. (1996), Oh et.al. (2005) Chiari-Andreo et al. (2017) Gayathri and Kiruba (2014) Bijauliya et al. (2018) Ashraf et al. (2016) Jassal and Kaushal (2019) Soliman et al. (2016) Liu et al. (2015) Wang et al. (2017) Yi-Ting et al. (2019) Diaz-de-Cerio et al. (2016) Abu-Bakr et al. (2003) Chen et al. (2006) Pino et al. (2002) Paniandy et al. (2000) Pino et al. (2001) Mercado-Silva et al. (1998) Jordan et al. (2003)

	Mecocyanin, Rubixanthin, Criptoflavin, Neochrome, Lutein, Phytofluene, Quercetin 3-α-L- arabinofuranoside, Quercetin-3-β-galactoside, Quercetin 3- β-D- galactoside, Avicularin, Amritoside	
Flower	Quercetin, Leucocyanidin, Kaempferol, Quercetin 3-α-L- arabinofuranoside, Kaempferol-3- glucoside, Psidium guajava coumari acid, Obtusinin	Begum et al. (2002a), Begum et al. (2002b), Begum et al. (2004c), Jordan et al. (2003), Pelegrini et al. (2008), Castro-Vargas et al. (2010)
Roots	Obtusinin, Gallic acid, Tannin, Leukocyanidins, sterols, tannic acid, Ellagic acid	Jordan et al. (2003)
Seeds	Glycosids, Carotenoids, Phenolic compounds, Flavonoid compounds, Flavonol glycoside, quercetin-3-O-β-D-(2''-Ogalloyglucoside)-4'-O-vinylpropionate, cylated flavonol glycoside, Arjunolic acid, Jacoumaric acid, 1-O-3,4-dimethyl-phenylethyl-4-o-3,4-dimethoxy cinnamoyl-6-o-cinnamoyl-β-D-glucopyranase, Mecocyanin, cylated flavonol glycoside	Pelegrini et al. (2008) Michael et al. (2002) Salib et al. (2004)
Bark	Polyphenols, Ellagic acid, Resins	Michael et al. (2002), Salib et al. (2004), Ryu et al. (2012), Rahim et al. (2010)

5. Conclusions

Psidium guajava fruits are promising due to their significant dietary value. They can be consumed raw or processed into various products such as jams, RTD beverages, Guava-enriched cheese, yogurt, and jellies. Additionally, the edible leaves of *Psidium guajava* have long been utilized in traditional medicine for their wide-ranging therapeutic benefits.Both the fruits and leaves of *Psidium guajava* contain diverse chemical constituents that contribute to their pharmacological effects, including antioxidant, anticancer, antidiabetic, and anti-inflammatory properties. While in vitro studies and animal trials have evaluated these pharmacological activities, there is limited data from recorded human trials. The dietary importance of *Psidium guajava* fruits and leaves is well-established; further research is necessary to confirm their nutraceutical and pharmacological properties.

6. References

Abu-Bakr, A., Abu-Goukh, Hind, A. B. (2003). Changes in pectic enzymes and cellulase activity during guava fruit ripening. *Food Chemistry*, 83, 213-218. https://doi.org/10.1016/S0308-8146(03)00067-0

Adrian, J.A.L., Arancon, N.Q., Mathews, B.W., Carpenter, J.R. (2015). Mineral composition and soil-plant relationships for common guava (*Psidium guajava* L.) and yellow strawberry guava (*Psidium cattleianum var. Lucidum*) tree parts and fruits. *Communications in Soil Science and Plant Analysis*,46(15),1960–1979.

https://doi.org/10.1080/00103624.2015.1069310

Adrees, M., Younis, M., Farooq, U., Hussain, K. (2010). Nutritional quality evaluation of different guava varieties. *Pakistan Journal of Agriculture Science,* 47(1),1-4.

Alhamdi, H., Boadi, W., Tiriveedhi, V., Garcia, A.,Driggins,S.N.,Myles,E.(2019).Investigating the anti-tumor potential of *Psidiumguajava* extracts on PC-3, A549, and BT-549. *MOJ Cell Science and Report*, 6(1),10–15.

Arima, H., Danno, G. (2002). Isolation of antimicrobial compounds from guava (*Psidium guajava* L.) and their structural elucidation. *Bioscience, Biotechnology and Biochemistry*,66, 1727–1730. https://doi.org/10.1271/bbb.66.1727

Arshiya, S. (2013). The antioxidant effect of certain fruits: A review. *Journal of Pharmaceutical Sciences and Research*,*5*(12),265-268

Ashraf, A., Sarfraz, R.A., Rashid,M.A., Mahmood, A., Shahid, M., Noor, N.(2016). Chemical composition, antioxidant, antitumor, anticancer and cytotoxic effects of *Psidium guajava* leaf extracts. *Pharmaceutical Biology*, 54(10),1971-1981.https://doi.org/10.3109/13880209.2015.1137604

Begum, S., Hassan, S.I., Siddiqui, B.S., (2002a). Two new triterpenoids from the fresh leaves of Psidium guajava. *Planta Medical* 68, 1149–1152.https://doi.org/10.1055/s-2002-36353

Begum, S., Hassan, S.I., Siddiqui, B.S., Shaheen, F., Ghayur, M.N., Gilani, A.H.(2002b). Triterpenoids from the leaves of Psidium guajava. *Phytochemistry*, 61, 399–403.https://doi.org/10.1016/S0031-9422(02)00190-5

Begum, S., Hassan, S.I., Siddiqui, B.S. (2004c.) Chemical constituents from the leaves of Psidium guajava. *Natural Product Research*,18,135–140. https://doi.org/10.1080/14786410310001608019

Bijauliya,R.K., Alok, S., Kumar, M., Chanchal, D.K., Sabharwal, M., Yadav, R.D.(2018). An update of pharmacological activity of Psidium guajava in the treatment of various diseases. *International Journal of Pharmaceutical Sciences and Research*, 9(3),883-893.

Bontempo, P., Doto, A., Miceli, M., Mita, L., Benedetti, R., Nebbioso, A., Veglione, M., Rigano, D., Cioffi, M., Sica, V., Molinari, A.M., Altucci, L.(2012) Psidium guajava L. anti-neoplastic effects: induction of apoptosis and cell differentiation.*Cell Proliferation*. 2012; 45(1),22-31. https://doi.org/10.1111/j.1365-2184.2011.00797.x

Bulk, R.E.E., Babiker, E.F.E, Tinay, A.H.E. (1996) Changes in chemical composition of guava fruits during development and ripening. *Food Chemistry*, 59, 395-399. https://doi.org/10.1016/S0308-8146(96)00271-3

Braga, T. , Dores, R. , Ramos, C. , Evangelista, F. , Tinoco, L. , Varotti, F. , Carvalho, M. and Sabino, A. (2014). Antioxidant, Antibacterial and Antitumor Activity of Ethanolic Extract of the *Psidium guajava* Leaves. *American Journal of Plant Sciences*, 5,3492-3500. doi: 10.4236/ajps.2014.523365.

Castro-Vargas, H. I., Rodríguez-Varela, L. I., Ferreira, S. R., Parada-Alfonso, F. (2010). Extraction of phenolic fraction from guava seeds (*Psidium guajava L.)* using supercritical carbon dioxide and co-solvents. *The Journal of Supercritical Fluids*, *51*(3),319-324.https://doi.org/10.1016/j.supflu.2009.10.012

Biswas, S., Talukdar, P., Talapatra, S. N. (2019). Presence of phytochemicals in fruits and leaves of guava (*Psidium guajava* Linn.) for cancer prevention: A mini review. *Journal of Drug Delivery and Therapeutics*, *9*(4-s), 726-729. https://doi.org/10.22270/jddt.v9i4-s.3290

Chah, K.F., Eze, C.A., Emuelosi, C.E., Esimone, C.O. (2006). Antibacterial and wound healing properties of methanolic extracts of some Nigerian medicinal plants. *Journal of Ethnopharmacology* ,*104*, 164–

167.https://doi.org/10.1016/j.jep.2005.08.070

Chiari-Andréo, B.G., Trovatti, E., Marto, J.M., Almeida-Cincotto, M.G., Melero, A., Correa, M.A., Chiavacci, L.A., Ribeiro, H.M., Garrigues, T.M., Isaac, V.L. (2017). Guava: phytochemical composition of a potential source of antioxidants for cosmetic and/or dermatological applications. *Brazilian Journal of Pharmaceutical Sciences,* 53, 1-10. DOI:10.1590/S2175-97902017000216141

Chen,Y.H., Zhou, T,. Zhang, Y.J., Zou, Z.F., Wang, F., Xu, D.P. (2015). Evaluation of antioxidant and anticancer activities of guava. *International Journal of Food Nutrition and Safety*, 6,1-9.

Chen, H.Y,. Yen, G.C,. (2007). Antioxidant activity and free radical-scavenging capacity of extracts from guava (*Psidium guajava* L.) leaves. *Food chemistry*, 101(2), 686-694. https://doi.org/10.1016/j.foodchem.2006.02.047

Chen, H.S., Sheu, M.J., Lin, L.Y,. Wu, C.M. (2006) .Characterization of volatiles in guava (*Psidium guajava* L. cv. Chung-Shan-Yueh-Pa) fruits from Taiwan. *Journal of Food Drug Analysis*,14(4),398-402. https://doi.org/10.38212/2224-6614.2463

Chauhan, A. K., Singh, S., Singh, R. P., & Singh, S. P. (2015). Guava-enriched dairy products: a review. *Indian Journal of Dairy Science*, 68(1), 01-05.

Chiveu, J., Naumann, M., Kehlenbeck, K., and Pawelzik, E. (2019). Variation in fruit chemical and mineral composition of Kenyan guava (*Psidium guajava* L.): Inferences from climatic conditions, and fruit morphological traits. *Journal of Applied Botany and Food Quality*, 92,151-159. https://doi.org/10.5073/JABFQ.2019.092.021

Cybele, E., Almeida, M.G.O., Karnikowski, R.F., Baldisserotto, B., 1995. Analysis of antidiarrhoeic effect of plants used in popular medicine. *Revista de Saude Publica* 29, 56–59. https://doi.org/10.1590/S0034-89101995000600002

Deguchi, Y., and Miyazaki, K. (2010). Anti-hyperglycemic and anti-hyperlipidemic effects of guava leaf extract. *Nutrition & metabolism*. 7(1),1-10. https://doi.org/10.1186/1743-7075-7-9

Díaz-de-Cerio, E., Verardo, V., Gómez-Caravaca, A. M., Fernández-Gutiérrez, A., Segura-Carretero, A. (2016). Exploratory characterization of phenolic compounds with demonstrated anti-diabetic activity in guava leaves at different Oxidation States. *International Journal of Molecular Sciences*. 17(5),699. https://doi.org/10.3390/ijms17050699

El-Sisy, W.A.A.Z. (2013). Evaluation of some genotypes of guava trees grown under lexandria Governorate condition I. Vegetative growth, flowering and fruit quality. *World Applied Sciences Journal* ,28 (4),583-595.

Gayathri, V,. Kiruba, D. (2014). Preliminary phytochemical analysis of leaf powder extracts of *Psidium guajava* L. *International Journal of Pharmacognosy and Phytochemical Research*. 6(2), 332-334.

Gull, J., Sultana, B., Anwar, F., Naseer, R., Ashraf, M., Ashrafuzzaman, M. (2012). Variation in antioxidant attributes at three ripening stages of guava (*Psidium guajava* L.) fruit from different geographical regions of Pakistan. *Molecules*,*17*(3), 3165-3180. https://doi.org/10.3390/molecules17033165

Gutiérrez, R. M. P., Mitchell, S., & Solis, R. V. (2008). Psidium guajava: A review of its traditional uses, phytochemistry and pharmacology. *Journal of ethnopharmacology*, 117(1), 1-27. https://doi.org/10.1016/j.jep.2008.01.025

He, Q., & Venant, N. (2004). Antioxidant power of phytochemicals from Psidium guajava leaf. *Journal of Zhejiang University-Science A*, *5*, 676-683.

Hung-Hui, C., Po-Hua, W., Diana, L., Yun-Chieh, P., Ming-Chang, W. (2011). Hepatoprotective effect of guava (*Psidium guajava* L.) Leaf extracts on ethanol-induced injury on clone 9 rat liver cells. *Food and Nutrition Sciences*, *2011*. 10.4236/fns.2011.29133

Jassal, K,. Kaushal, S.(2019). Phytochemical and antioxidant screening of guava (Psidium guajava) leaf essential oil. Agricultural Research Journal. 2019, 56, 528 -533. 10.5958/2395-146X.2019.00082.6

Joseph, B., & Priya, M. (2011). Review on nutritional, medicinal and pharmacological properties of guava (Psidium guajava Linn.). *International Journal of pharma and bio sciences*, *2*(1), 53-69.

Jordán, M.J., Margaría, C.A., Shaw, P.E., Goodner, K.L.(2003). Volatile components and aroma active compounds in aqueous essence and fresh pink guava fruit puree (*Psidium guajava* L.) by GC-MS and Multidimensional GC/GC-O. *Journal of Agricultural and Food Chemistry*, 51, 1421-1426 . https://doi.org/10.1021/jf020765l

Kamath,J.V., Rahul, N., Ashok Kumar, C.K.A., Lakshmi, S.M. (2008). *Psidium guajava* L: A review. *International Journal of Green Pharmacy.*2(1),9-13.

Kanwal, N., Randhawa, M., Iqbal, Z. (2016). A Review of Production, Losses and Processing Technologies of Guava. *Asian Journal of Agriculture and Food Sciences,*4(2),96-101.

Kumar, M., Tomar, M., Amarowicz, R., Saurabh, V., Nair, M. S., Maheshwari, C., Satankar, V. (2021). Guava (*Psidium guajava* L.) leaves: nutritional composition, phytochemical profile, and health-promoting bioactivities, *Foods*, 10(4), 752. https://doi.org/10.3390/foods10040752

Leonti, M., Vibrans, H., Sticher, O., Heinrich, M. (2001). Ethnopharmacology of the Popoluca, Mexico: An evaluation. *Journal of Pharmacy and Pharmacology,* 53, 1653–1669. https://doi.org/10.1211/0022357011778052

Liang, Q., Qian, H., Yao, W.(2005). Identification of flavonoids and their glycosides by high-performance liquid chromatography with electrospray ionization mass spectrometry and with diode array ultraviolet detection. *European Journal of Mass Spectrometry* 11, 93–101. https://doi.org/10.1255/ejms.710

Liu, C.W., Wang, Y.C., Lu, H.C., Chiang, W.D. (2015). Guava (Psidium guajava Linn.) leaf extract promotes glucose uptake and glycogen accumulation by modulating the insulin signaling pathway in high-glucose-induced insulin-resistant mouse FL83B cells. *Process. Biochemistry*,49,1601–1605. https://doi.org/10.1016/j.procbio.2015.03.022

Luo, Y., Peng, B., Wei, W., Tian, X., and Wu, Z. (2019). Antioxidant and anti-diabetic activities of polysaccharides from guava leaves. *Molecules*,24(7),1343 https://doi.org/10.3390/molecules24071343

Marsh, K., Richardson, A., Macrae, E.(1999). Early-and mid-season temperature effects on the growth and composition of satsuma mandarins. *Journal of Horticultural Sciences and Biotechnol*ogy. 74, 443-451. https://doi.org/10.1080/14620316.1999.11511135

Mazumdar, S., Akter, R., Talukder, D. (2015). Antidiabetic and antidiarrhoeal effects on ethanolic extract of *Psidium guajava* (L.) Bat. leaves in Wister rats. *Asian Pacific Journal of Tropical Biomedicine*, 5(1),10-14.https://doi.org/10.1016/S2221-1691(15)30163-5

Mercado-Silva, E., Benito-Bautista, P., Ma de los Angeles García-Velasco, M. (1998). Fruit development, harvest index and ripening changes of guavas produced in central Mexico. P*ostharvest Biology and Technology*,13,143-150. https://doi.org/10.1016/S0925-5214(98)00003-9

Michael H.N., Salib J.Y., Ishak M.S. (2002). Acylated flavonol glycoside from *Psidium guajava* L. seeds, *Die Pharmazie*, 57(12),859- 60.

Musa, K.H., Abdullah, A., Jusoh, K., Subramaniam, V. (2011). Antioxidant activity of pink-flesh guava (*Psidium guajava* L.): Effect of extraction techniques and solvents. *Food Analysis Methods*, 4(1),100-107. https://doi.org/10.1007/s12161-010-9139-3

Nantitanon, W., Yotsawimonwat, S., Okonogi, S. (2010). Factors influencing antioxidant activities and total phenolic content of guava leaf extract. *LWT-Food science and technology*. 43(7),1095-1103. https://doi.org/10.1016/j.lwt.2010.02.015

Oh, W.K., Lee, C.H., Lee, M.S., Bae, E.Y., Sohn, C.B., Oh, H., Kim, B.Y., Ahn, J.S., (2005). Antidiabetic effects of extracts from Psidium guajava. *Journal of Ethnopharmacology*, 96, 411–415, https://doi.org/10.1016/j.jep.2004.09.041

Oliveira, D.D.S., Lobato, A.L., Ribeiro, S.M.R.,Santana, A.M.C., Chaves, J.B.P., Pinheiro-Sant'Ana,H.M.(2010). Carotenoids and Vitamin C during Handling and Distribution of Guava (*Psidium guajava L.*), Mango (*Mangifera indica L.*), and Papaya (*Carica papaya L.)* at Commercial Restaurants. *Journal of Agriculture and Food Chemistry*. 58(10), 6166-6172. https://doi.org/10.1021/jf903734x

Omayio, D. G., Abong, G. O., OKoth, M. W., Gachuiri, C. K., Mwangombe, A. W. (2019). Current status of guava (*Psidium Guajava* L.) production, utilization, processing and preservation in Kenya: a review, *Current Agriculture Research Journal* , 7(3), 318.

Pakpahan, E.L., Alveolie Gabriella.B.D.S., Melisa, B.D.S.(2013). *In vitro* anticancer activity of guava (*Psidium guajava L.)* against HSC-2 human oral cancer cells. *Dental Students Research*, 1, 16-20

Paniandy, J.C, Chane-Ming, J., Pieribattesti, J.C. (2000) Chemical composition of the essential oil and headspace solid-phase microextraction of the guava fruit (*Psidium guajava* L.). *Journal of Essential Oil Research,*12,153-158. https://doi.org/10.1080/10412905.2000.9699486

Parvez, G. M., Shakib, U., Khokon, M., Sanzia, M. (2018). A short review on a nutritional fruit: guava. *Open Access: Toxicology and Research*, 1-8.

Patel, R. K., Maiti, C. S., Deka, B. C., Deshmukh, N. A., Roy, D. (2011). Variability studies in guava (*Psidium guajava* L.) genotypes for growth, yield and quality attributes at mid-hills of Meghalaya. *Indian Journal of Hill Farming*, 24(1),24-8.

Pelegrini, P.B., Murad, A.M., Silva, L.P., Dos Santos, R.C., Costa, F.T., Tagliari, P.D. et al. (2008) Identification of a novel storage glycine-rich peptide from guava (*Psidium guajava*) seeds with activity against Gram-negative bacteria. *Peptides*, 29(8),1271-1279. https://doi.org/10.1016/j.peptides.2008.03.013

Pino, J.A., Marbot, R., Vázquez, C.(2002) Characterization of volatiles in Costa Rican guava [Psidium friedrichsthalianum (Berg) Niedenzu] fruit. *Journal of Agricultural and Food Chemistry* 50, 6023-6026.

Prabu, G.R., Gnanamani, A., Sadulla, S. (2006). Guaijaverin - a plant flavonoid as potential antiplaque agent against *Streptococcus mutans*. *Journal of Applied Microbiology* 101, 487–495.

Qadan, F., Thewaini, A.J., Ali, D.A., Afifi, R., Elkhawad, A., Matalka, K.Z. (2005). The antimicrobial activities of *Psidium guajava* and *Juglans regia* leaf extracts to acne-developing organisms. *American Journal of Chineese Medicine*, 33(2), 197-204.

Rahim, N., Gomes, D.J., Watanabe, H., Rahman, S.R., Chomvarin, C., Endtz, H.P. et al. (2010). Antibacterial activity of *Psidium guajava* leaf and bark against multidrug-resistant *Vibrio cholerae*: implication for cholera control. *Japanese Journal of Infectious Diseases*, 63, 271-274.

Rawi, S. M., Mourad, I. M., Sayed, D. A. (2011). Biochemical changes in experimental diabetes before and after treatment with *Mangifera indica* and Psidium guava extracts. *International Journal of Pharmacy and BioScience*, 2(2), 29-41.

Ryu, N. H., Park, K. R., Kim, S. M., Yun, H. M., Nam, D., Lee, S. G. et al. (2012). A hexane fraction of guava leaves (*Psidium guajava L.*) induces anticancer activity by suppressing AKT/mammalian target of rapamycin/ribosomal p70 S6 kinase in human prostate cancer cells. *Journal of medicinal food*, *15*(3), 231-241. https://doi.org/10.1089/jmf.2011.1701

Salib, J.Y., Michael, H.N.(2004). Cytotoxic phenylethanol glycosides from *Psidium guaijava* seeds. Phytochemistry 65, 2091–2093.https://doi.org/10.1016/j.phytochem.2004.06.009

Sanz, M.L., Villamiel, M.,Martínez-Castro, I. (2004). Inositols and carbohydrates in different fresh fruit juices. *Food Chemistry,*87,325-328. https://doi.org/10.1016/j.foodchem.2003.12.001

Sato, J., Goto, K., Nanjo, F., Hawai, S., Murata, K.(2000). Antifungal activity of plant extracts against *Arthrinium sacchari* and *Chaetomium funicola*. *Journal of Biochemical Engineering and Sciences*, *90,*442–446. https://doi.org/10.1016/S1389-1723(01)80016-5

Sato, R., Dang, K. M., McPherson, B. G., & Brown, A. C. (2010). Anticancer activity of guava (*Psidium guajava*) extracts. *Journal of Complementary and Integrative Medicine*, *7*(1).

Sharma, R. R. (2012). Preliminary phytochemical screening of some indigenous medicinal plant leaves extract in regulation of antidiabetic activity. *Science Research Reporter*, 2(3), 307-310.

Shukla, K., and Dubey, P. K. (2009). Antidiabetic Activity of *Psidium guajava* (Guava) Leaves Extract. *Research Journal of Science and Technology*, 1(3),13-15.

Sing, G., Sahare, H. Deep, M. (2019). Recent Trends in Guava Propagation -A Review. *Biosciences Biotechnology Reserach Asia*. 16(1),143-15. http://dx.doi.org/10.13005/bbra/2732.

Smith, N. J., Williams, J. T., Plucknett, D. L., & Talbot, J. P. (2018). *Tropical forests and their crops*. Cornell University Press.

Soliman, F. M., Fathy, M. M., Salama, M. M., & Saber, F. R. (2016). Comparative study of the volatile oil content and antimicrobial activity of Psidium guajava L. and Psidium cattleianum Sabine leaves. *Bulletin of Faculty of Pharmacy, Cairo University*, *54*(2),219-225. https://doi.org/10.1016/j.bfopcu.2016.06.003

Tayyab, F., Lal, S. S., Mishra, M., Kumar, U. (2012). A review: Medicinal plants and its impact on diabetes. *World Journal of Pharmaceutical Research*, 1(4), 1019-1046.

Thaipong, K., Boonprakob, U., Cisneros-Zevallos, L. and Byrne, D.H. (2005). Hydrophilic and lipophilic antioxidant activities of guava fruits. *Southeast Asian journal of tropical medicine and public health*,36,254.

Thuaytong, W., & Anprung, P. (2011). Bioactive compounds and prebiotic activity in Thailand-grown red and white guava fruit (*Psidium guajava* L.). *Food Science and Technology International*, *17*(3), 205-212. https://doi.org/10.1177/1082013210382066

Tona, L., Kambu, K., Ngimbi, N., Cimanga, K., & Vlietinck, A. J. (1998). Antiamoebic and phytochemical screening of some Congolese medicinal plants. *Journal of ethnopharmacology*, *61*(1), 57-65. https://doi.org/10.1016/S03788741(98)00015-4

Vikrant, A., Thakur, N., Kashyap, C.P. (2012). Preliminary Phytochemical Analysis of the Extracts of *Psidium Leaves. Journal of Pharmacognosy and Phytochemistry*, 1(1),01-05.

Wang, L., Wu, Y., Bei, Q., Shi, K.,Wu, Z. (2017). Fingerprint profiles of flavonoid compounds from *different Psidium guajava leaves* and their antioxidant activities. *Journal of Separation Science*, 40(19), 3817-3829. https://doi.org/10.1002/jssc.201700477

Yi-Ting, W., Chih-Hui, Y., Ting-Yu, H., Mi-Hsueh Tai, Ru-Han Sie, & Shaw, J. (2019). Cytotoxic Effects of Chlorophyllides in Ethanol Crude Extracts from Plant Leaves. *Evidence-Based Complementary and Alternative Medicine, 2019*, 13. https://doi.org/10.1155/2019/9494328